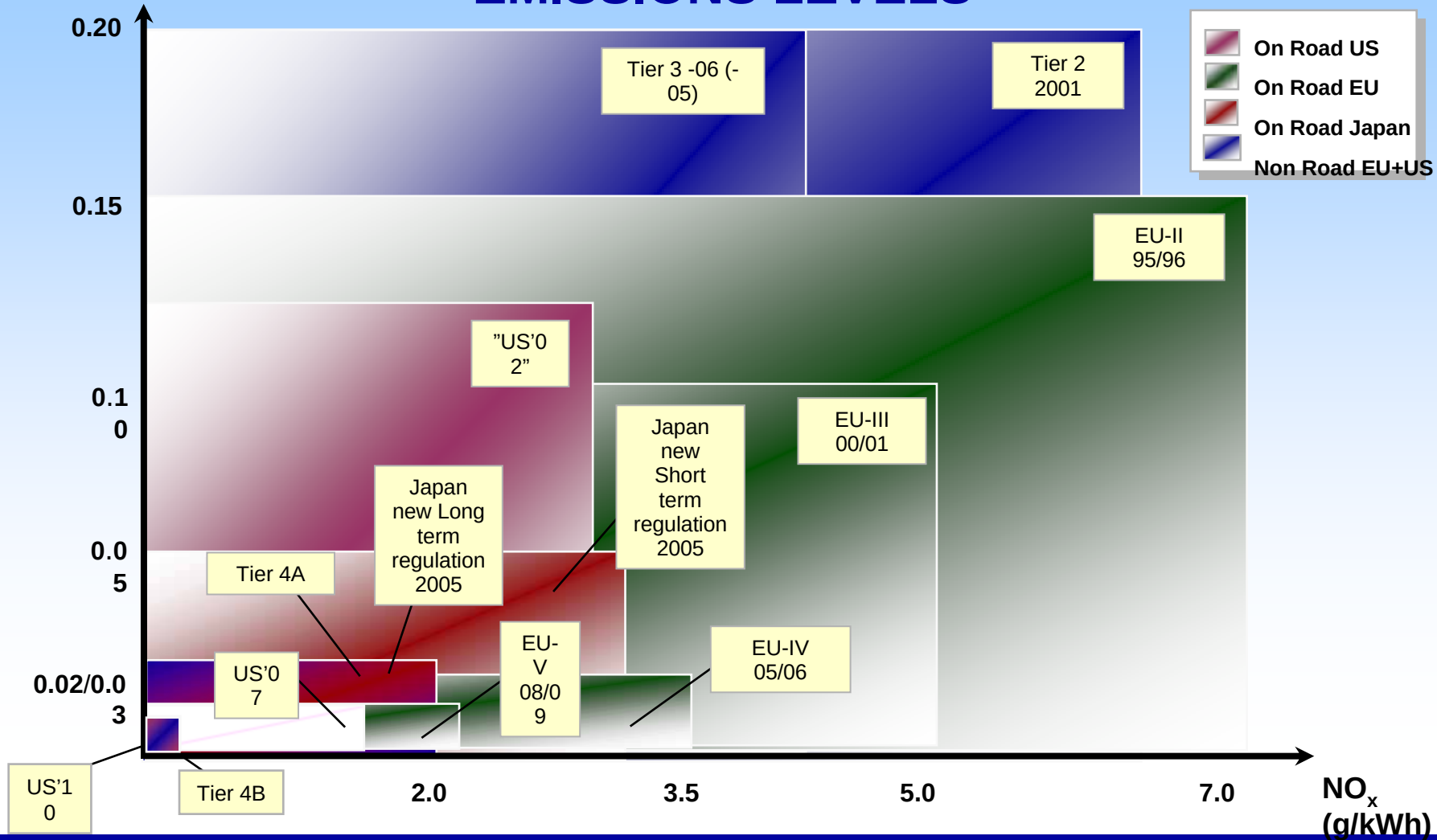
A EUROPEAN PERSPECTIVE OF EURO 5/U.S. 07 HEAVY-DUTY ENGINE TECHNOLOGIES AND THEIR RELATED CONSEQUENCES

OUTLINE

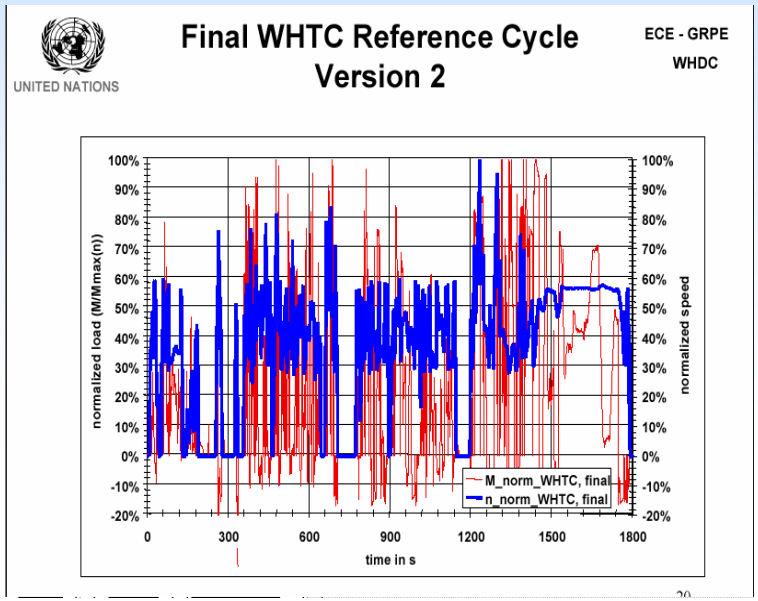
- Regulations Background
  - ✓ Emissions Control Technologies
    - Selection
    - Comparison
  - ✓ UREA/AD BLUE in Europe
  - ✓ European Regulations vs SCR
  - ✓ Perspective

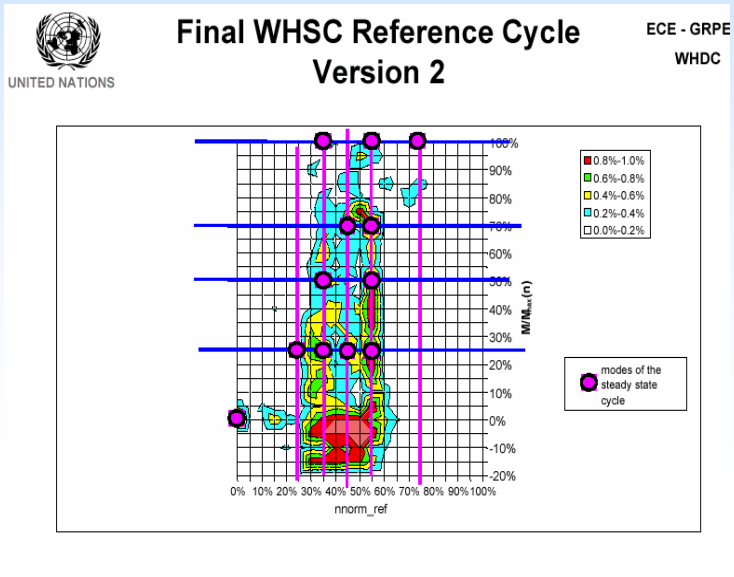
REGULATIONS BACKGROUND 1
EMISSIONS LEVELS



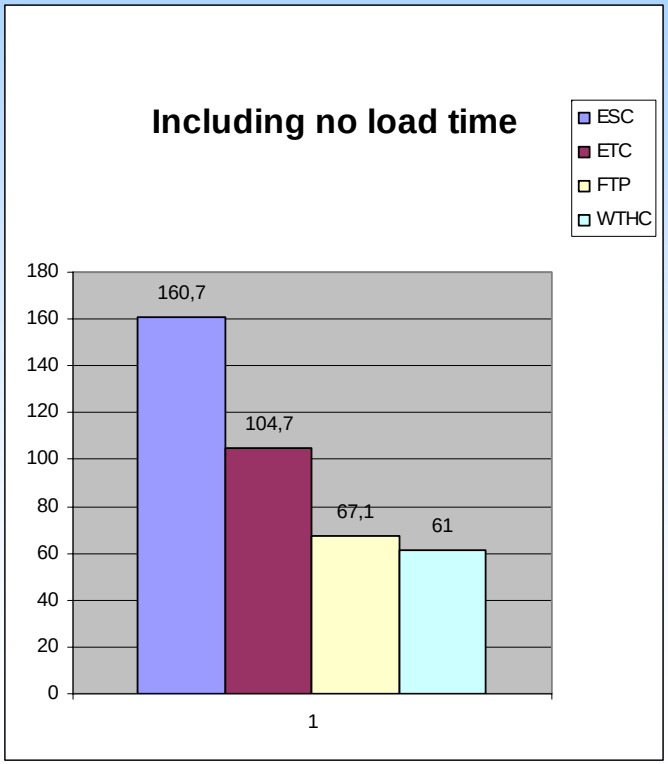
REGULATIONS BACKGROUND 2
EMISSIONS TESTS PROCEDURES 1

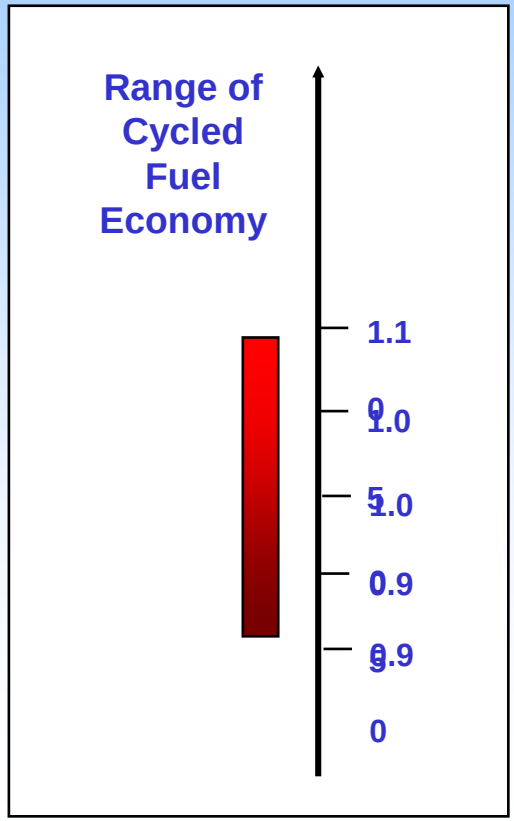
- Convergence, but a large panel of tests, Including steady state, transcient cycles and NTE limits
- Lack of harmonization
- Attempt to harmonize





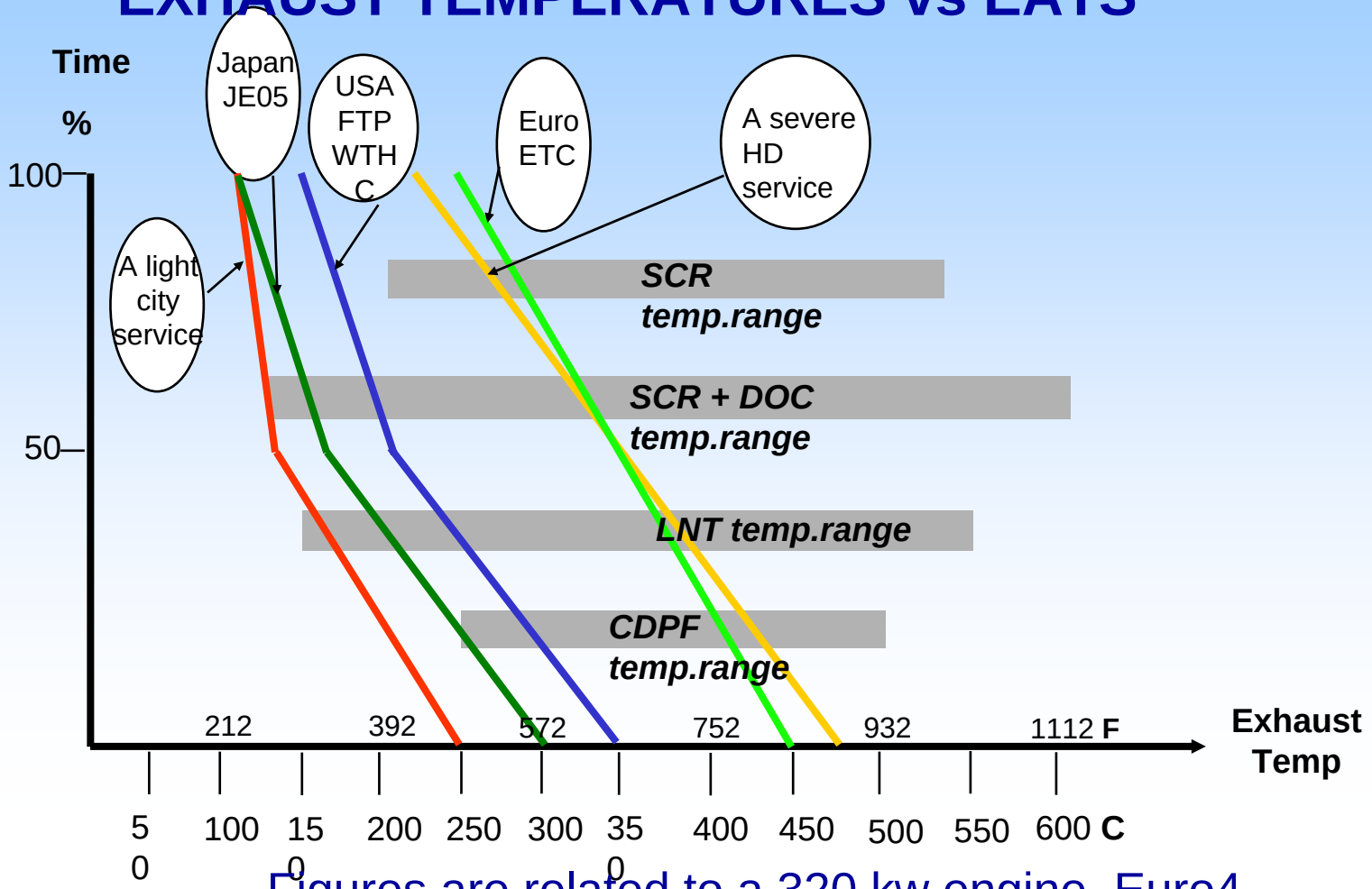
REGULATIONS BACKGROUND 3
EMISSIONS TESTS PROCEDURES 2
POWER and FUEL CONSUMPTION





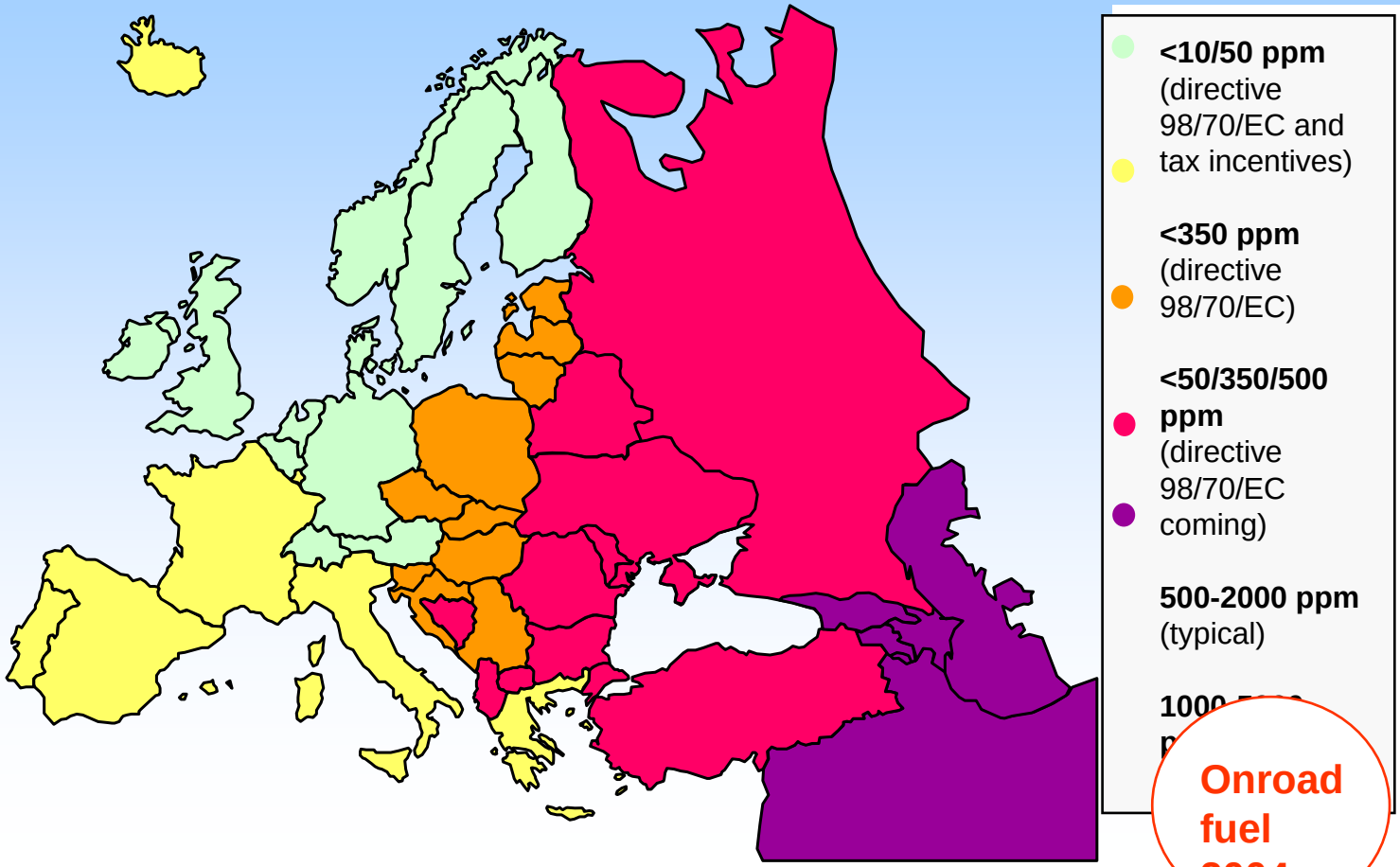
Figures are related to a 320 kw/429 hp - 2000 mN/1475 lb ft engine rating

REGULATIONS BACKGROUND 4
EMISSIONS TESTS PROCEDURES 3
EXHAUST TEMPERATURES vs EATS



Figures are related to a 320 kw engine, Euro4

REGULATIONS BACKGROUND 5
FUEL SULFUR CONTENT 1



EMISSIONS CONTROL 1
SELECTION of TECHNOLOGIES 1
DILEMMA

Low NOx

Low Part

High Fuel Economy

Low Initial Cost

Low Maintenance Cost

High Durability

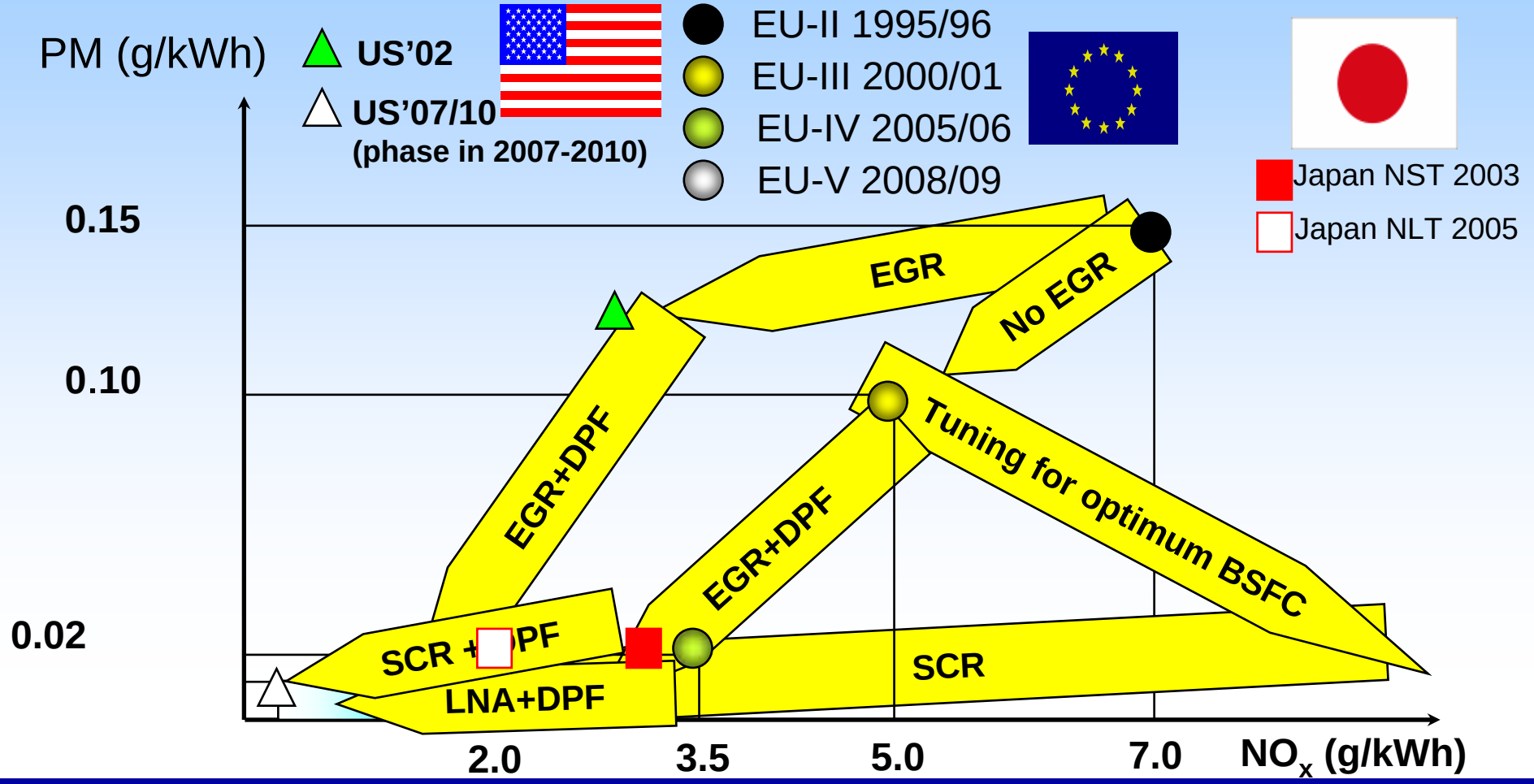
High Return on Investment

Regulations demand

Customer demand

OEM demand

EMISSIONS CONTROL 2
SELECTION of TECHNOLOGIES 2
MAIN ROUTES



EMISSIONS CONTROL 3
SELECTION of TECHNOLOGIES 3

- The Volvo group has selected:
  - ✓ SCR to control NOx in Europe
  - ✓ EGR to control NOx in North America
  - ✓ DPF to control particulates on both sides of the Atlantic

EMISSIONS CONTROL 4 TECHNOLOGIES COMPARISON 1 ASSUMPTIONS

- Comparison, as fair as possible, is proposed:
  - ✓ Euro 5, for the time being (NOx 2 gr/kwh – Part 0.02 gr/kwh) is less severe than U.S. 7
  - ✓ A Euro 5+, similar to US 07, is defined for the sake of comparison
  - ✓ A 11-l engine, 410 bhp/306 kW rated, is selected as reference

EMISSIONS CONTROL 5 TECHNOLOGIES COMPARISON 2 OVERALL

	EGR	SCR
Engine and Chassis Fuel Economy		
Bmep		
Heat Rejection and Chassis Cooling		
Weight		
Engine Durability		
Global System Cost		
Maintenance Cost		
Service Cost		
Development Cost		

Same hardware conditions

EMISSIONS CONTROL 6 TECHNOLOGIES COMPARISON 3 SYSTEMS ECONOMICS

SCR EGR	
Base Engine Cost	1.000 1.055
NOx System Cost	0.155 0.060
NOx System Chassis Overcost	0.009 0.015
DPF System	0.140 0.140
DPF System Chassis Overcost	0.007 0.007
	1.311 1.277

EMISSIONS CONTROL 7
TECHNOLOGIES COMPARISON 4
FUEL ECONOMY 1

ESC comparison of US 07/E 5+ engine (410bhp/306 kW)

raw figures (UREA consumption excluded)

SCR	0.94
EGR	1.01

EMISSIONS CONTROL 8
TECHNOLOGIES COMPARISON 5
FUEL ECONOMY 2

Net figures (UREA consumption included)

UREA prices assumed to be equal to :

100% of fuel one in North America

50% of fuel one in Europe

Engine and Urea effect	SCR	*EU*	0,97	SCR	*NA*	1,00
	EGR	*EU*	1,01	EGR	*NA*	1,01
Chassis and cooling effect	SCR	*EU*	0,97	SCR	*NA*	1,00
	EGR	*EU*	1,02	EGR	*NA*	1,02

EMISSIONS CONTROL 9
TECHNOLOGIES COMPARISON 6
CO 2 ASPECT

- 1 kg UREA needs 1 kg CO 2 to be PRODUCED
  A 6 % UREA consumption is assumed.

  on a steady-state cycle basis it comes a CO 2 rejection of :

  SCR 628 gr/kwh
  EGR 668 gr/kwh

EMISSIONS CONTROL 10
TECHNOLOGIES COMPARISON 7
ECONOMICS 1
ANNUAL OPERATING COST

Service : mix of intensive and economic N.A. HD long haul, medium severity

Costs : fuel and urea ($ 2/US gal)

engine maintenance & service

chassis maintenance & service

ESTIMATION of a mean A.O.C INCREASE (vs 04) :

EGR $ 500

SCR $ 50

EMISSIONS CONTROL 11
TECHNOLOGIES COMPARISON 8
ECONOMICS 2
ANNUAL VALUE IMPACT for CUSTOMER

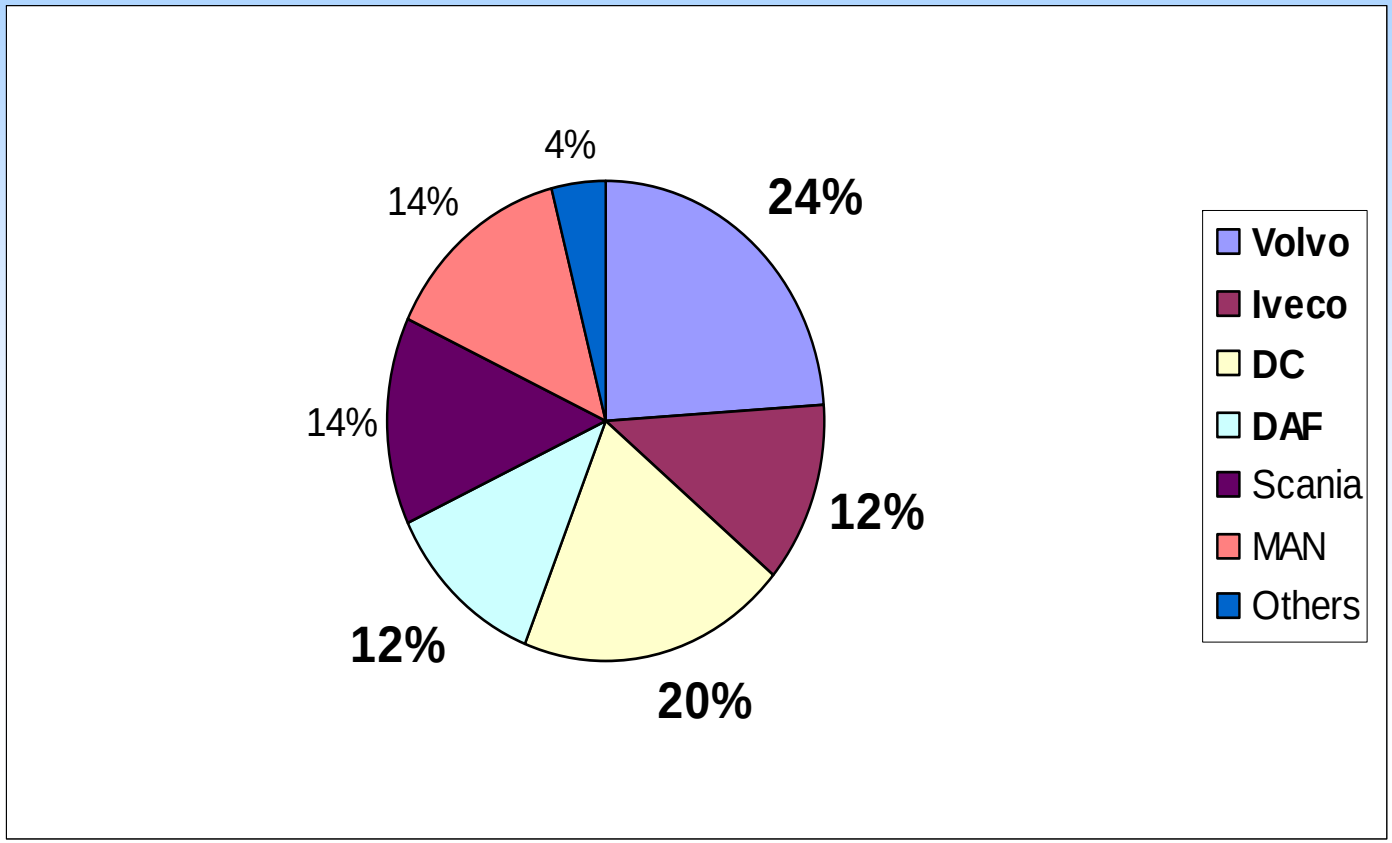
Service and Maintenance cost impact
Weight impact
Product Cost impact
Fuel cost
Residual Value impact
Project Development cost impact
N.A., mix of economic & intensive H.D long haul, medium severity service

E **ESTIMATION of a mean A.V.I., DETRIMENTAL (vs 04) by :**

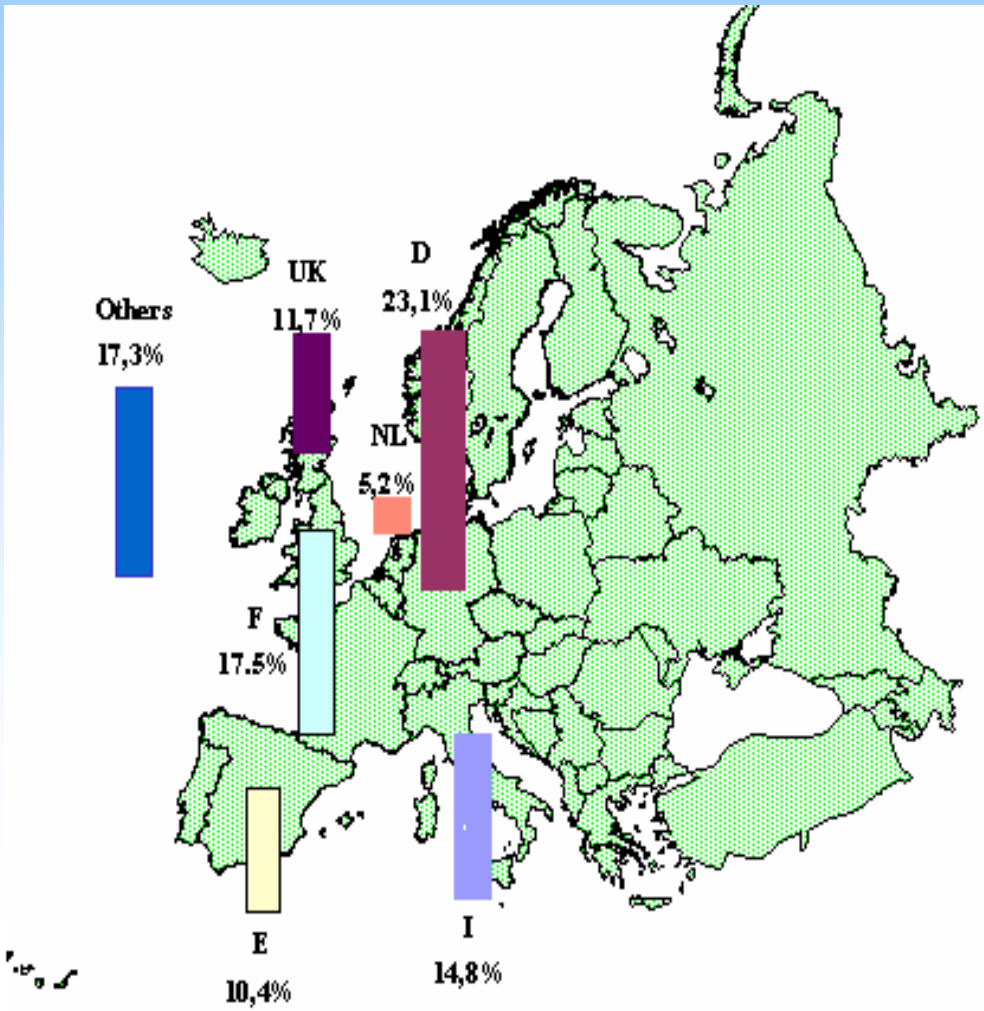
EGR $ 2000

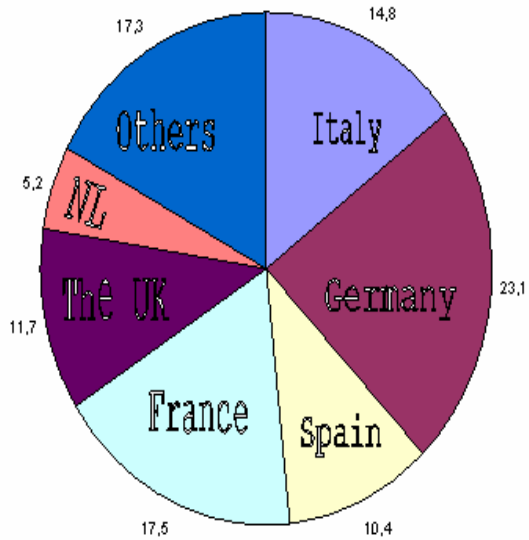
SCR $ 1500

UREA/AD BLUE in EUROPE 1
UREA/AD BLUE DEMAND in WESTERN EUROPE 1
HD VEHICLES MARKET > 16 T vs SCR



UREA/AD BLUE in EUROPE 2
UREA/AD BLUE DEMAND in WESTERN EUROPE 2

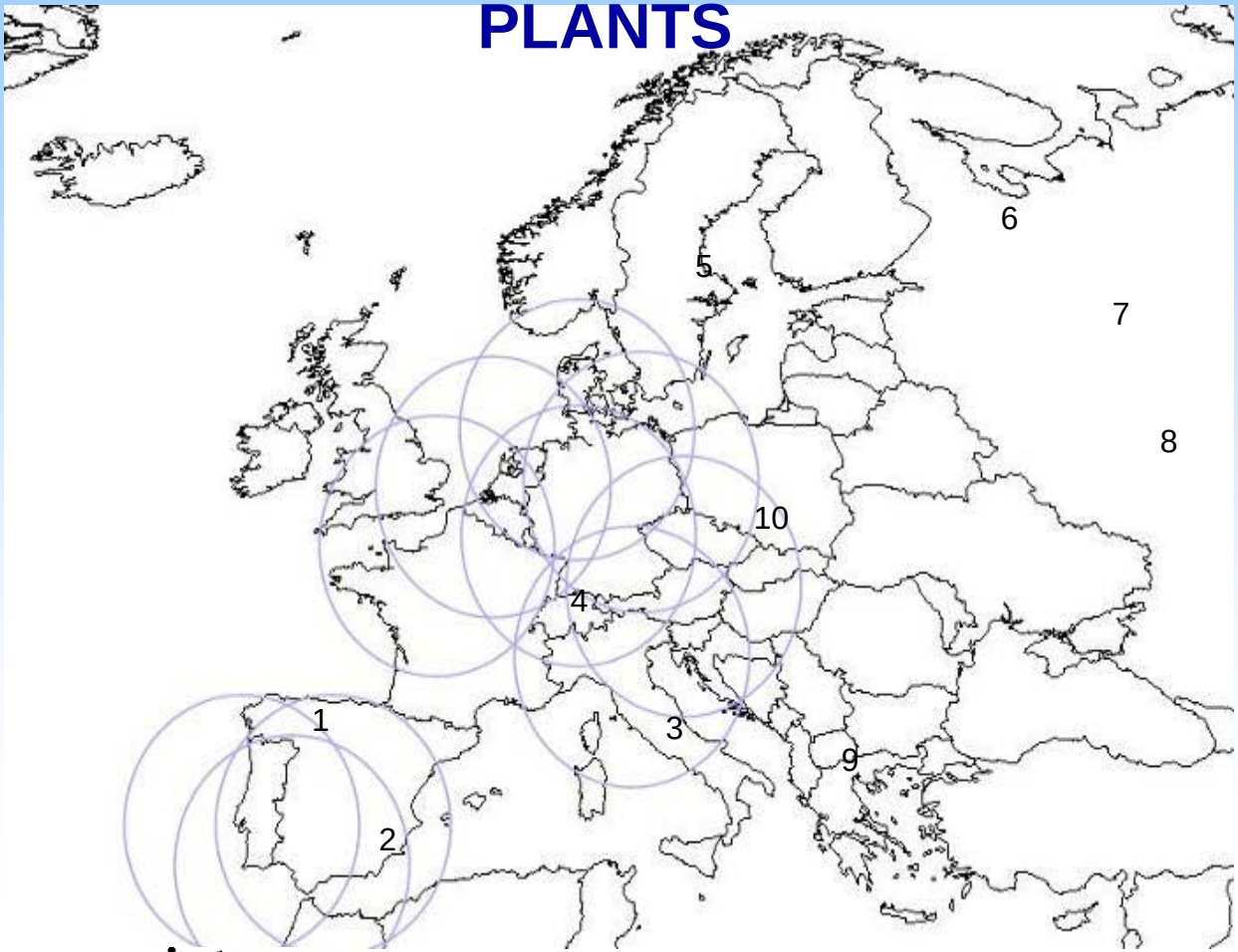




2.5 MT in 2010

Source **ACEA**

UREA/AD BLUE in EUROPE 3
300 m/500 km DISTRIBUTION RADIUS for UREA PLANTS



Source integer

UREA/AD BLUE in EUROPE 4
AD BLUE DISTRIBUTION 1

DISTRIBUTION TECHNOLOGIES and STRATEGIES are DEFINED or CLOSED to BE

(indoor, outdoor conditions, cans, containers, pumps, nozzles, bulk direct service to big fleets,...)

PRICING RANGE from 0,3 to 0,7 €/l

STATIONS TWO AD BLUE FILLING STATIONS RUNNING in Germany

ONE to be OPENED SHORTLY in France

UREA/AD BLUE in EUROPE 5
AD BLUE DISTRIBUTION 2
FILLING STATION and HARDWARE

Open/Closed system at home filling depot

Spill free nozzle

Discussions running

EURO REGULATION vs SCR 1
RESPONSIBILITY of the MEMBERS STATE

In the recitals of the comitology directive,

The commission recalls the responsibility of the member states :

to perform road side spot-checks for enforcing the proper operation of vehicles equipped with SCR

The commission requests the member states :

to ensure that urea will be available on a geographically balanced basis

to make illegal to drive without urea or not to consume urea

Discussions running

EURO REGULATION vs SCR 2
ANTI TAMPERING 1
OVERALL

As from EURO 4, day 1, the following tampering scenarios must be detectable

lack of reagent in the urea tank

non appropriate reagent consumption

As from EURO 4 or at a later date must be also detected a

wrong reagent quality or a lack of NOx reduction

As from EURO 4 or at a later date

all the above will lead to a two-step power reduction

Discussions running

EURO REGULATION vs SCR 3
ANTI TAMPERING 2
LACK of UREA

The level of urea in the tank must be monitored.

The level of urea in the tank must be indicated to the driver.

A lack of urea in the tank shall lead to :

- light on the OBD-indicator
- activate an additional warning mode on the dash board
- activate a reduction scheme in the engine performance

Discussions running

EURO REGULATION vs SCR 5
ANTI TAMPERING 3
UREA CONSUMPTION

The following parameters must be monitored :

- The level of urea in the tank
- The activity of the dosing system
- The urea injection

The urea consumption must be recorded.

A lack of urea consumption is diagnosed in the case of a too high difference

(50%) with the average consumption of the previous days and leads to :

- Light on the OBD indicator

Discussions running

EURO REGULATION vs SCR 4
ANTI TAMPERING 4
UREA QUALITY

The urea quality must be monitored : a quality deviating from the one specified by the manufacturer must be considered as a failure by the OBD system, and shall lead to light on the OBD-indicator.

Alternatively NOx reduction could be monitored.

Discussions running

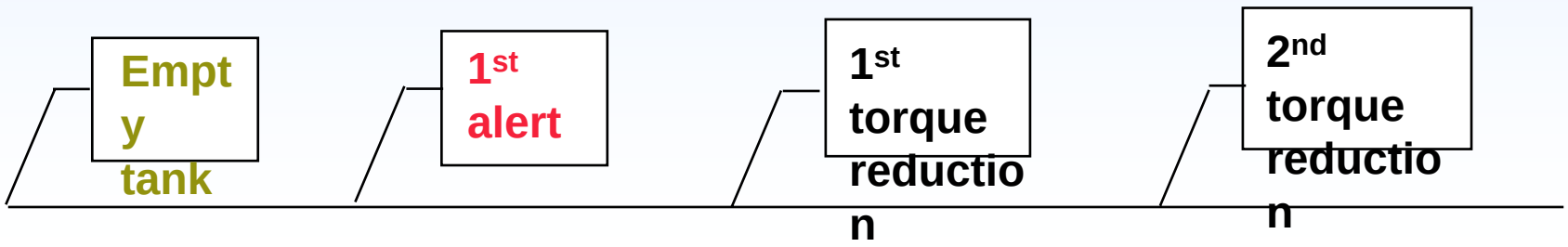
EURO REGULATION vs SCR 6
ANTI TAMPERING 5
REDUCTION of ENGINE TORQUE

2 steps reduction:

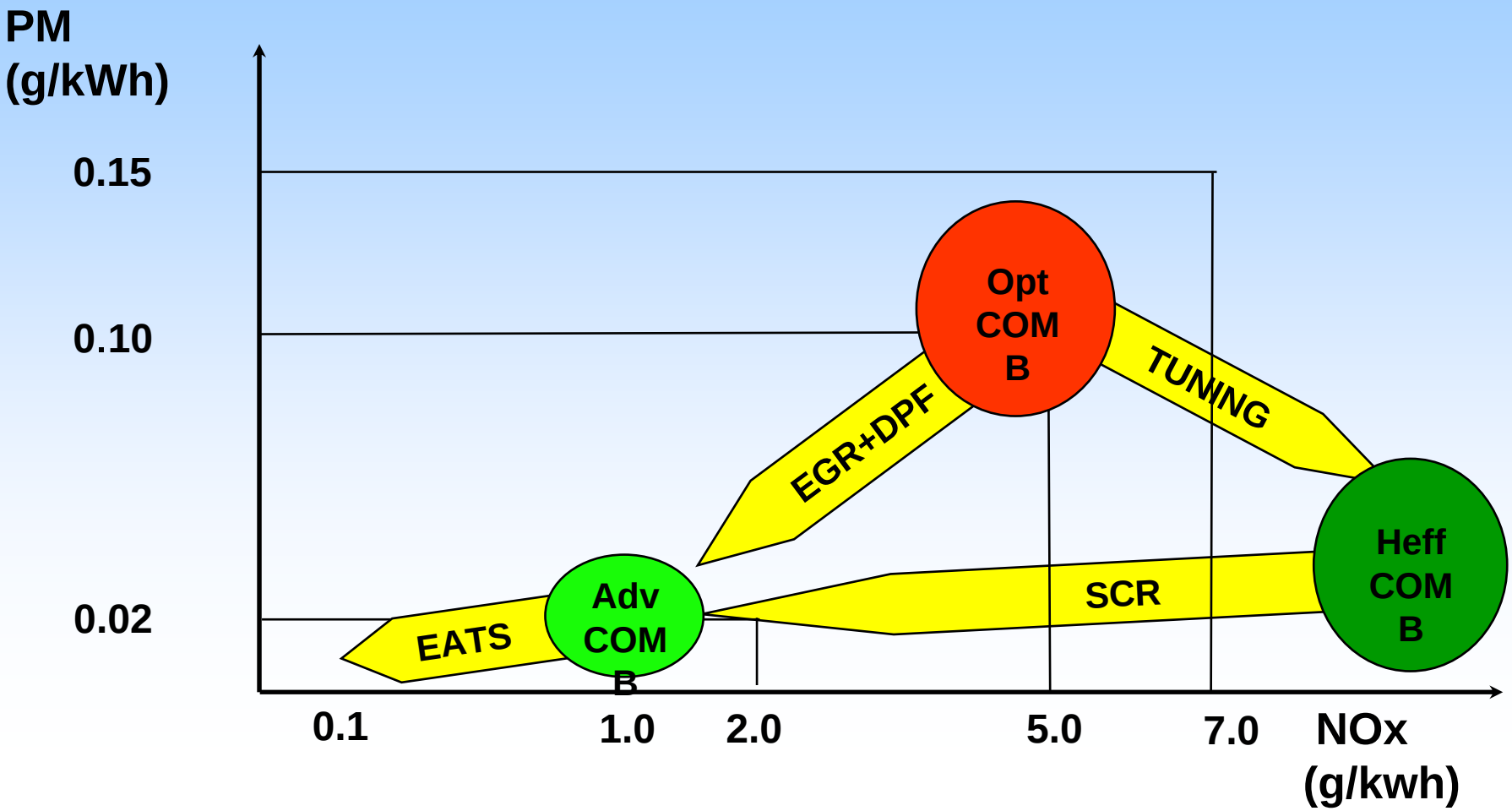
75% of the full load torque

60% of the full load torque

Torque reduction procedure to be considered for safety and environmental issues.



PERSPECTIVE 1
SIMPLIFIED ROUTES



PERSPECTIVE 2
KEY DRIVERS to the FUTURE

GLOBAL COST

PRODUCT, SERVICE, RELIABILITY/DURABILITY

SAVE OUR CUSTOMERS PROFITABILITY

by MANAGEMENT OF COMPLEXITY

FUEL ECONOMY and IN USE COST

SAVE DIESEL LOW CO 2 EMISSION POTENTIAL

REGULATIONS "AS USUAL"

BALANCE of CO 2/NO x EMISSIONS

THANKS FOR YOUR ATTENTION